The *Pileus Project*: Climate Science in Support of Decision Making

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A Few Years ago...

Mid April, 2002, a week of abnormally warm weather spread across Michigan. While most people welcomed the warmer temperatures after five months of winter, fruit growers were nervous. The early summer-like temperatures brought over-wintering trees out of dormancy and promoted early development. This was followed by several mornings of prolonged freezing temperatures which resulted in cold injury and a reduction in crop yield potential.

In the following weeks...

Cool, wet, windy weather and another series of freezes combined to reduce the tart cherry crop by 90% statewide. Because 70% of U.S. tart cherry industry's production is located in Michigan, the economic damage was staggering.

Although cherries in storage helped ease the blow, what most people in the tart cherry and other fruit industries wanted to know was: "Could this happen again? Are the past 3-5 years of below average yields a fluke or this becoming normal?"

What information do I need to support strategic decisions, where climate is a driving variable, in tart cherry production?

What are the *key* questions?

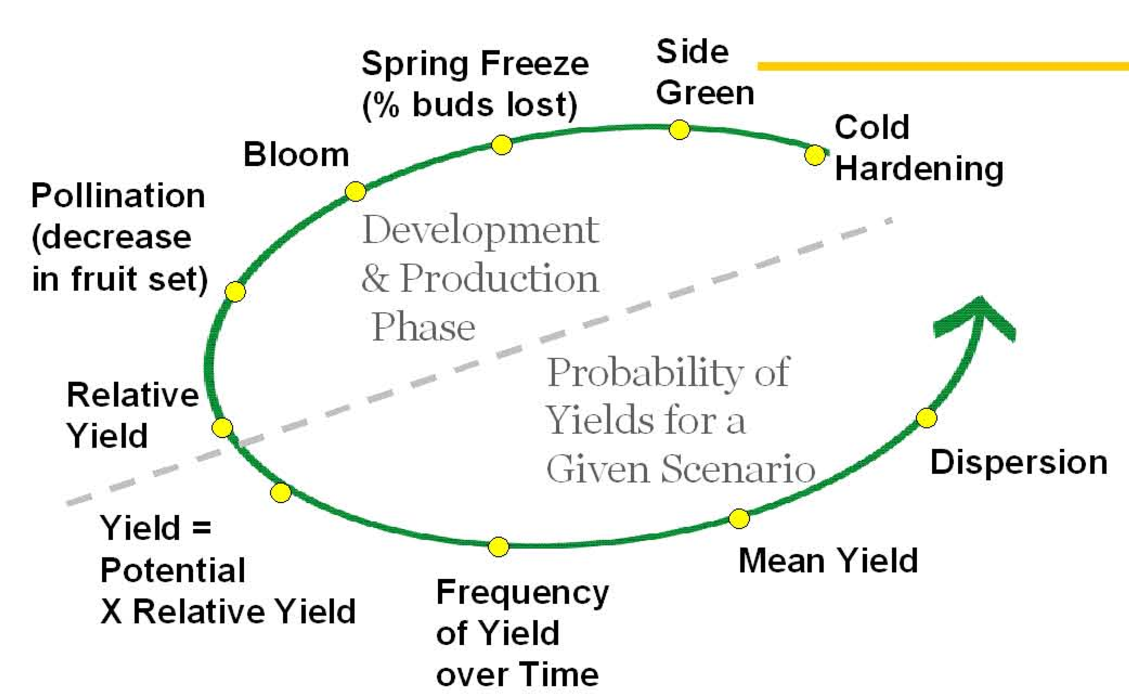
- Should a farm invest or re-invest (e.g., replace an existing block of trees) in tart cherry production recognizing that this is a 20 to 30 year commitment?
- Should a crop insurance program be developed for the tart cherry enterprise on farms to partially ameliorate financial risk exposure?

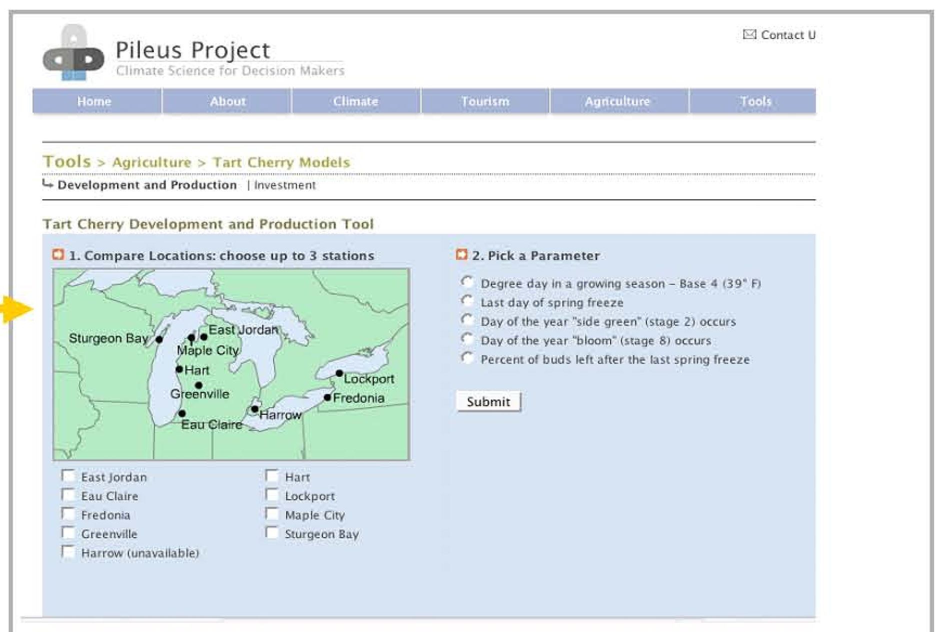
In order to understand production, researchers need to model *how* the system works

Model stages of flower bud/fruit development → Look at weather events at each stage to examine if they will reduce yield, and if so, by how much? → Relative yield

What is the level of detail needed to drive the yield model?

Daily weather data is required. The model needs to define the state of the system on a given day, evaluate the potential vulnerability to damaging weather events, detect if a damaging weather event has occurred, and estimate the impact on yield.

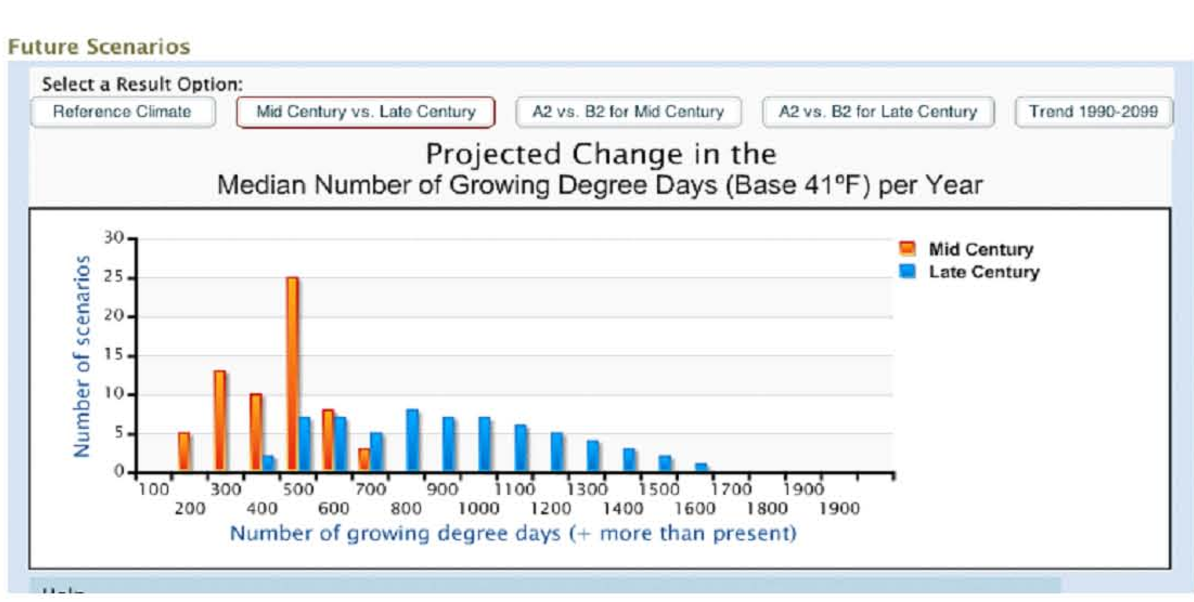




Phenological and yield models, developed specifically for the *Pileus Project*, are available for use with the ***Tart Cherry Development and Production Tool***. The user can investigate how a cherry tree might produce fruit and the associated frequency of alternative yields and mean yields, based on historical climate data or alternative future climate scenarios.

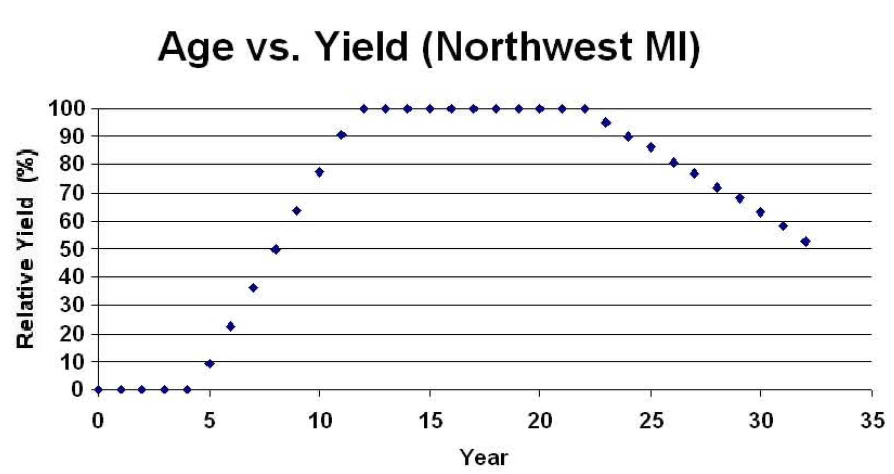
How might climate change in the future?

The ***Future Scenarios Tool*** allows users to evaluate how climate may change in the future. Simulations from four GCMs (CCSM1.2, CGCM2, ECHAM4, HadCM3) driven with two emissions scenarios (A2, B2) were downscaled for nine tart cherry locales in the Great Lakes region, using multiple downscaling methodologies. The resulting daily temperature and precipitation scenarios were converted to stakeholder-relevant indices and threshold variables (such as the date of last spring frost). The graphical output displays the projections from the entire suite (or ensemble) of scenarios. The range of projected changes is a proxy indicator of the degree of uncertainty surrounding the projections.

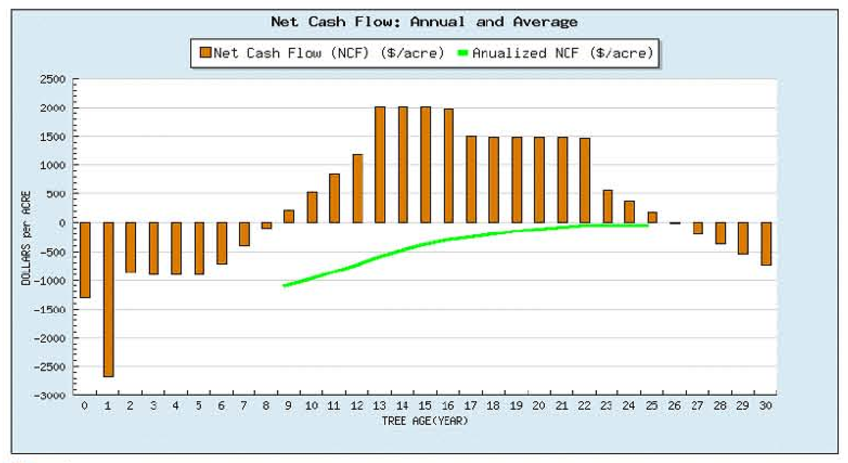


What are the impacts of climate scenarios on profitability and financial risk?

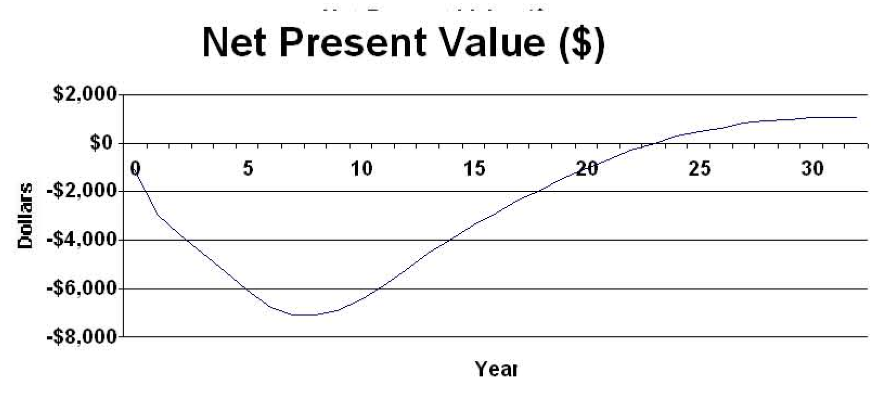
Investment Analysis



The ***Tart Cherry Investment/Replant Decision Tool*** has five components, most of which vary over the 20-30 year planning horizon: (1) tart cherry yield and fruit quality versus age of tree; (2) price trajectory; (3) cash requirements versus age of tree; (4) interest rate /discount factor; and (5) variability in price and yield and the price-yield correlation. One of the challenges is to normalize the uneven life-cycle annual net cash flows for risk and time; this is done using net present value (NPV) and, in some instance, NPV adjusted using a *Real Options* approach to value flexibility.



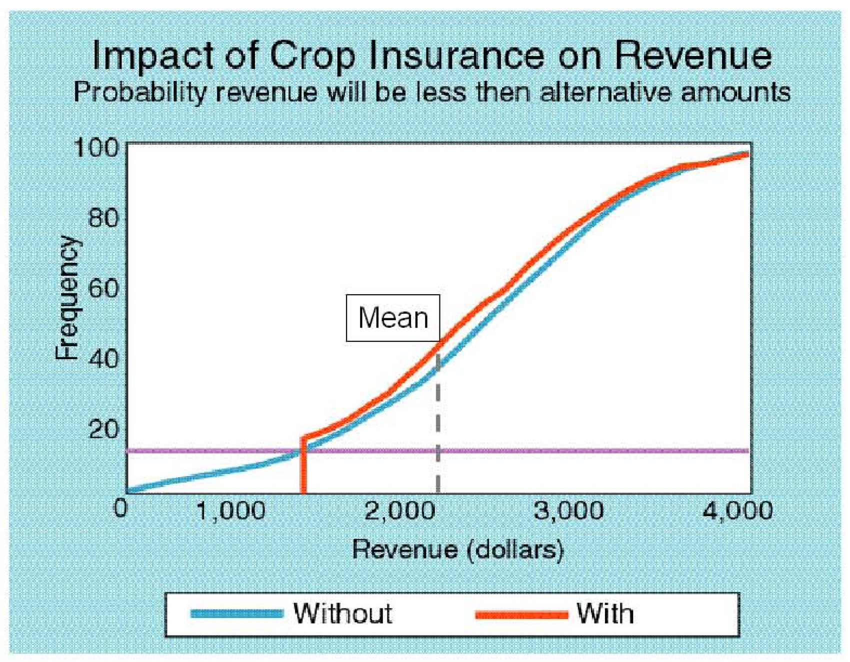
Climate change impacts all components. The 1st step in running the tool is to describe the potential yield versus age of tree (shown in the graph to the left). The 2nd step is to calculate a weighted average yield for each age by multiplying potential yield by relative yield and weighting by the frequency of relative yields. The 3rd step is to estimate the price scenario associated with the climate scenario. The remaining steps calculate the annual cash flow (shown in the graph to the left).



The decision to invest is based on the net present value (NPV) for a given economic life of the cherry tree. The NPV is obtained by discounting annual cash flows by the risk adjusted interest rate, and summing them to get the NPV for a given economic lifetime (shown in the graph to the left). This tool is also designed to employ both historical climate observations and future climate scenarios.

The risk analysis option permits estimation of the frequency distribution of NPVs based upon a simulation where yields and prices are drawn from a joint probability distribution associated with a scenario. Histograms can be compared for historical versus alternative future scenarios.

Insurance



The relative variability of revenue for the tart cherry enterprise is in the top 5% of agricultural enterprises. The federal government facilitates either yield or revenue insurance for a number of crop enterprises, but not tart cherries. The federal government is involved in insurance, partly because of the systemic nature of yield variability across space which has limited private sector activity. The insurance tool is designed to illustrate the premium cost and financial risk transfer for alternative contract designs. Design parameters include deductible and co-pay choices. Farm information that influences rate includes indicators of site characteristics. The risk transfer is evaluated for both historical weather and future scenarios.

The objective of insurance is to mitigate the effects on net cash flow of unfavorable events. The farm transfers this financial risk to the insurance pool for a fee – the insurance premium. One way of showing farmers and lenders how an insurance design works is to describe the probability that revenue will not fall below levels that are critical to the farm business under insurance versus no insurance. The graph shows the probability the revenue will be less than alternative values described on the horizontal axis – the cumulative probability. In the example, a 30% deductible was chosen which ensures there is a only 17% chance that revenue will not be less than $1,375/acre. The mean revenue is $2,250.